IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of:	) Atty. Docket No.: **SUGI0085**
	) Confirmation No.: 8194
Keiichiro OISHI	)
	)
Serial No. 09/983,029	) Group Art Unit: 1742
	)
Filed: October 22, 2001	)
	) Examiner: SIKYIN IP
For: COPPER/ZINC ALLOYS HAVING LOW LEVELS OF LEAD AND GOOD MACHINABILITY	)

DECLARATION OF KEIICHIRO OISHI UNDER 37 C.F.R. § 1.132

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

1. I, Keiichiro OISHI, state that I am an expert in the field of metal alloy research and development. Specifically, I am the head of the Research and Development Center at Sambo Copper Alloy Co., Ltd., 8-374, Sambo-cho, Sakai-shi, Osaka, Japan, 590-0906 (hereafter, the "Sambo R&D Center").

2. I am familiar with the above captioned application and claims. In this declaration, I submit experimental evidence demonstrating the superior and unexpected properties achieved by the free-cutting copper alloys in accordance with the present invention, as defined by claims 1-14 of the above captioned patent application, over the closest prior art, and to provide my testimony regarding the effects of metal phase on the characteristics of metal alloys. Metal alloys made in accordance with the present invention are intended for use in manufacturing water faucets, water supply/drainage metal fittings and valves, and like components for water supply lines, and therefore must have excellent machinability characteristics.

3. The following experimental results are the product of tests lead by me and conducted under my supervision at the Sambo R&D Center from December 2003 to January 2004.

4. The present experiment consisted of comparing metal alloy Comparative Samples No. 1 to No. 4 (corresponding to or approximating the prior art with modifications as discussed below) with Samples Nos. 5 and 6 (present invention), and Sample No. 7 (modified alloy). See Table I attached hereto. Comparative Samples Nos. 8.1, 8.2, 9.1 and 9.2 were tested to demonstrate the effect of subjecting metal alloy compositions to hot extrusion temperatures at the upper and lower working temperature limits for Cu-Zn(Pb) alloys.

<u>Samples Modeling Nakashima's Alloys</u>

5. The closest prior art to the metal alloys in accordance with claims 1-14 of the present invention is believed to be the Cu-Zn alloys of Examples A through C, and the Cu-Zn(Pb) alloy of Example D, shown in Table 1 of U.S. Patent 5,582,281 (hereafter, the "Nakashima Patent"). However, these alloys of Examples A through D are relatively hard, poorly machinable metals, having Hardness Rockwell B values of more than 80, and are intended for use to make sliding members for a vehicle transmission (See Abstract of Nakashima Patent).

6. The corresponding Cu-Zn(Pb) alloys of Comparative Samples No. 1 to No. 3 used in the present experiment have almost the same compositions as the Cu-Zn alloys of Examples A through C of Table 1 of the Nakashima Patent. However, because Pb content greatly affects machinability, 0.2% of Pb was added by weight to the compositions of Examples A through C of the Nakashima Patent to provide metal alloy compositions for Comparative Samples No. 1

to No. 3 with enhanced machinability characteristics. Without the addition of some Pb, those skilled in the art would expect that these metal alloy compositions taught by the Nakashima Patent, having Hardness Rockwell B values of 80 or more, would have exceptionally poor machinability characteristics. In general, as the hardness of a metal increases, the machinablility tends to decrease. However, the κ, γ and μ phases formed in copper alloys of the present invention work to improve machinability even for hard metals. Consequently, while some of the copper alloys made in accordance with the present invention have maximum Hardness Rockwell B values of about 95, these metals still have superior machinability as a result of the claimed combination of phases.

7. Thus, I believe that the addition of lead in small amounts was a reasonable modification of the exact Cu-Zn compositions taught by the Nakashima Patent, and results in comparison alloys that are closer to the present invention than those cited in the prior art of the Nakashima Patent. In other words, Comparative Samples Nos. 1 to 3 are experimental alloys created to more closely approximate, or model, the Cu-Zn(Pb) alloys of the present invention than would be achieved by comparing the unmodified Cu-Zn alloys of the Nakashima Patent.

8. On the other hand, the Cu-Zn(Pb) alloy of Comparative Sample No. 4 corresponds to the Cu-Zn(Pb) alloy of Example 4 of the Nakashima Patent within acceptable experimental error.

Samples Representing the Present Invention

9. Samples No. 5 and No. 6 are free-cutting copper alloys made in accordance with the broad first embodiment of the present invention, which is recited in original claim 1 and

covered by the scope of original claim 13. Samples Nos. 5 and 6 are Cu-Zn(Pb) metal alloys having percentages of β phase that are extremely small (i.e., about 1% and 4%, respectively). These alloys each have 0.15% of Pb by weight.

<u>Comparative Sample No. 7</u>

10. Comparative Sample No. 7 is a free-cutting copper alloy similar to those of Samples Nos. 5 and 6, except that the percentage of β phase is 10% of the metal phase construction. Comparative Sample No. 7 is included to demonstrate the undesirable effect on the state of chippings and corrosion resistance when β phase is present in excess of 5%. Comparative Sample No. 7 is an alloy containing 0.15% of Pb by weight.

11. Sample Nos. 1 to 7 were formed as described at paragraph [0050] of the above-captioned specification. Specifically, Samples Nos. 1 to 7 were formed as round bars having circular cross-section with an outside diameter of 15 mm, with the compositions and metal phase constructs given in Table I, by heating cylindrical ingots of 100 mm in outside diameter and 150 mm in length to 750°C and hot-extruding the same. The cylindrical ingots had the compositions given in Table I attached hereto.

12. Comparative Samples Nos. 8.1 and 8.2 have the same metal alloy composition as Comparative Sample No. 4; therefore, cylindrical ingots of the same metal alloy composition were used to form Comparative Samples Nos. 4, 8.1 and 8.2. However, Comparative Samples Nos. 8.1 and 8.2 were produced by heating the cylindrical ingots to 800°C and 650°C, respectively, and hot extruding the same. Likewise, Comparative Samples Nos. 9.1 and 9.2 have the same metal alloy composition as Sample No. 6 (present invention); therefore,

cylindrical ingots of the same metal alloy composition were used to form Samples Nos. 6, 9.1 and 9.2. However, Comparative Samples Nos. 9.1 and 9.2 were produced by heating the cylindrical ingots to 800°C and 650°C, respectively, and hot extruding the same.

The Cutting Tests

13. Cutting tests were then carried out on each sample in accordance with the technique described in paragraph [0052] of the present specification. Specifically, each sample was cut on its circumferential surface using (i) a lathe provided with a point nose straight tool at a rake angle of ~ 8 degrees, (ii) at a cutting rate of 50 meters/min, (iii) to a cutting depth of 1.5 mm, and (iv) at a feed rate of 0.11 mm/rev. The cutting tests allowed evaluation and comparison of the various samples on the basis of (a) cutting force, (b) condition of chippings, and (c) the cut surface condition.

14. Signals from a three-component dynamometer mounted on the point nose straight tool were converted into electric voltage signals, which were then converted into cutting resistance. While cutting resistance is the sum of three component forces (i.e., cutting force, feed force, and thrust force), the feed force and thrust force are negligible under the conditions of the present experiments so the cutting resistance is approximately equal to the cutting force. The results of the measurements of cutting resistance are provided in Table I, attached hereto.

Evaluation of Chippings

15. Chippings from the cutting test were collected, examined and classified in accordance with the four forms (A) to (D) shown in Figure 1, and described in paragraph [0053], of the present application. Specifically, the chippings were classified as follows: (A) fine needle,

represented as "o;" (B) best chippings, represented as "•;" (C) spiral arc, represented as "Δ;" and (D) spiral windings, represented as "x" in Table I. The desired chippings are the "best chippings." The disadvantages of the fine needle, spiral arc, and spiral windings chipping forms are discussed in paragraph [0053] of the present specification. The results of evaluating the condition of the chippings are provided in Table I.

Cut Surface Condition Evaluation

16. The surface condition of the cut metal surface was also evaluated after cutting to determine the maximum roughness (Rmax), which is a commonly used standard in the art for measuring surface roughness as described in paragraph [0054] of the present specification. Specifically, alloys with an Rmax < 10 microns are generally considered to have excellent machinability (represented by "o" in Table I), whereas alloys with an Rmax in the range 10 microns ≤ Rmax < 15 microns are generally considered to be industrially acceptable (represented by "Δ" in Table I), and alloys with an Rmax ≥ 15 microns are generally judged to have poor machinability (represented by "x" in Table I). The results of the determination of the cut surface state for each sample are provided in Table I.

De-zinc-ing Corrosion Test

17. Sample Nos. 5, 6, 7, 9.1 and 9.2 were also subjected to the de-zinc-ing corrosion test in accordance with the "ISO 6509" method, which is a standard test in the art described in paragraph [0061] of the present specification. Specifically, each one of these samples was embedded in a phenolic resin in such a way so that the exposed sample surface is perpendicular to the extrusion direction of the sample. The surface of the sample was then polished with emery paper No. 1200, and then ultra-sonic washed in pure water and dried.

After this initial preparation, each prepared sample was dipped in a 12.7 g/l aqueous solution of cupric chloride dihydrate ($CuCl_2 \cdot 2\ H_2O$) 1% and left standing for 24 hours at 75°C. Each dipped sample was then taken out of the aqueous solution and the maximum depth of de-zinc-ing corrosion was then measured. The results of the de-zinc-ing corrosion test are provided in Table I.

Background Discussion

18. Before discussing the data provided in Table I, I will discuss the following background information for the record. First, the amount and kind of metal phase construction forming metal materials is affected (a) by the alloy composition, (b) by the processing/production conditions (i.e., the hot extrusion temperature) and (c) by the processing method. The data in Table I provides examples showing how independently both the hot working temperature and the metal composition can affect the percentage amount of phase β as well as the percentages of other metal phases that form the alloy. For example, Samples Nos. 5 and 6 and Comparative Sample No. 7 show that when the processing conditions and the processing methods have been determined, then a critical metal composition can be determined where the β phase is formed as 5% or less of the total phase construction.

19. In other words, while the critical value of the β phase (i.e., 5% or less) is determined by three parameters, which are (i) metal composition, (ii) processing conditions (i.e., the extrusion temperature), and (iii) the processing method, fixing two of these parameters (i)-(iii) allows for the critical value of the third parameter to be determined that corresponds to the formation of the critical value of the β phase (i.e., β phase is 5% or less). Consequently, those skilled in the art would realize that three parameters determine when the β phase will reach the

critical value and the β phase critical value of 5% is not determined solely on the basis of metal composition alone.

20. These examples also show how the machinability of the metal alloys is affected by changing the metal phase construction. For this experiment, the relative percentages of the various metal phases (i.e., α, β, γ, κ, and μ) making up the metal phase construction (i.e., total phase area) for each Sample in Table I was estimated by examining a thin slice of each sample alloy under a microscope at a magnification of 200. A photograph showing the phase construction for each sample is attached as Exhibits A, B, C and D, wherein: A shows a metal phase construction photograph for Comparative Samples Nos. 1 to 4; B shows a metal phase construction photograph for Samples Nos. 5, 6 and Comparative Sample No. 7; C shows a metal phase construction photograph for Comparative Samples Nos. 8.1 and 8.2; and D shows a metal phase construction photograph for Comparative Samples Nos. 9.1 and 9.2. The percentage of each phase was estimated as the ratio of area containing a specific phase to the total area of metal surface examined (i.e., total phase area).

21. Second, generally speaking, the hot working temperature for Cu-Zn(Pb) alloys, such as free-cutting brass JIS Designation C3604, C3602 (Copper Development Association Inc. (CDA) Designation C36000) with Pb added, and of brass for molding JIS Designation C3771 (CDA Designation C37700) with Pb added, is known to be about 650°C to 850°C. For this experiment, Comparative Samples Nos. 8.1, 8.2, 9.1 and 9.2 have been subjected to hot extrusion temperatures at the upper and lower temperature limits of the working range to demonstrate that not all temperatures in the working range cause the desired metal phase constructs to form.

Test Results and Discussion

22. As shown in Table I, Comparative Samples No. 1 to No. 4, which were made to correspond to metal alloys taught by the Nakashima Patent, but better approximate the present invention, all manifest serious disadvantages compared to the Cu-Zn(Pb) metal alloys in accordance with the present invention as represented by Samples No. 5 and No. 6. Specifically, the chippings collected and examined after cutting work was completed on each Comparative Sample Nos. 1 to 4 were the long and connected chippings of the spiral windings type even though 0.2% Pb by weight had been added to some of these alloys. On the other hand, the chippings collected and examined after cutting work was completed on each Sample Nos. 5 and 6 of the present invention were of the best chipping type. As explained in the instant specification, in paragraph [0053], metal alloys such as provided by Comparative Samples Nos. 1 to 4 are disadvantageous because spiral type chippings are generated during cutting work, which are difficult to recover or recycle, and may get tangled with the cutting tool thereby damaging the cut metal surface and the tool. In contrast, metal alloys made in accordance with the present invention, as represented by Samples Nos. 5 and 6 according to the present invention, produce the desired "best chippings," which can be efficiently recycled or recovered, and which are unlikely to damage the cut metal surface or the cutting tool.

23. As shown in Table I attached hereto, the cut surface state was not qualitatively different between the metal alloys of Comparative Samples Nos. 1 to 4 that model the prior art, and the metal alloys of Samples Nos. 5 and 6 made in accordance with the present invention.

24. As shown in Table I, the cutting force required to cut metal alloys of Comparative Samples Nos. 1 to 4, which model the prior art, is extremely great and exceeds 200 N, which is about twice the cutting force required to cut the metal alloys of Samples Nos. 5 and 6 made in accordance with the present invention. The extremely great cutting force needed to machine metal alloy Samples Nos. 1 to 4 is also about twice the cutting force required to generally machine free cutting brasses containing about 3 % lead as supported in Table 33 of the instant specification (See cutting forces for Samples Nos. 13001, 13002 and 13003, which underwent the same cutting test method as described in paragraph 11 above). Thus, the cutting force required to machine Zn-Cu(Pb) alloys made in accordance with the present invention is on the order of 100 N, which manifests a machinability property that is industrially acceptable and similar to that manifested by prior art Cu-Zn(Pb) alloys containing about 3 % Pb. On the other hand, the Zn-Cu(Pb) alloys of Comparative Samples Nos. 1 to 4, 8.1 and 8.2, which reasonably approximate the hard metal alloys taught by the Nakashima Patent, require cutting forces that are industrially out of the question. Therefore, these alloys demonstrate unsatisfactory machinability for the purpose of manufacturing water faucets, water supply/drainage metal fittings and valves, and like components for water supply lines.

Effect of Varying Extrusion Temperature on Sample No. 4

25. Furthermore, even when Cu-Zn(Pb) alloy having the same composition as Comparative Sample No. 4 is subjected to a different hot extrusion temperature, such as shown by Comparative Samples Nos. 8.1 and 8.2, the β phase of the metal construct remains very high. This phase behavior results in the observation that both the cutting resistance and the state of the chippings do not change for metal alloys having the same metal composition as

Comparative Sample No. 4 despite varying the hot extrusion temperature within the known working range for Cu-Zn(Pb) alloys. In other words, in my opinion, it is reasonable to conclude from the phase behavior of Comparative Samples Nos. 4, 8.1 and 8.2 that the machinability of Comparative Samples Nos. 1 to 3 will not be improved by altering the hot extrusion temperature.

26. In addition, the Cu-Zn(Pb) alloy Comparative Samples Nos. 1 to 4, 8.1 and 8.2 all produce the unacceptable spiral winding chippings when machined, whereas Samples Nos. 5 and 6 according to the present invention each produce the desired "best chippings." Therefore, in my opinion, it is reasonable to conclude that the production of unacceptable spiral winding chippings, when machining metal alloys made to have a composition similar to Comparative Samples Nos. 1 to 4, would be unaffected by changing the hot extrusion temperature.

Effect of Varying the Copper Content on the Present Invention Alloys

27. The machinability properties of Samples Nos. 5 to 7 demonstrate other important characteristics of Cu-Zn(Pb) metal alloys made in accordance with the present invention. Specifically, as the Cu content of a metal alloy made in accordance with Sample No. 5 is decreased while the Zn content is increased, the percentage of the β phase also increases as shown in Table I attached hereto. As the percentage of β phase increases, so too does the cutting force and the chippings tend to become more connected to each other. In fact, when the β phase reaches 10%, as occurred with Comparative Sample No. 7, the cutting resistance observed during cutting had risen to 138 N, which is about 35% higher than the cutting force used to cut generally free cutting brasses containing 3% Pb (i.e., See Samples Nos. 13001,

13002, 13003 from Table 33 of the instant specification). In addition, the character of the chippings changes when a β phase of 10% is observed. Specifically, once the β phase of the Cu-Zn(Pb) metal alloy reaches 10% (i.e., exceeds about 5%) the chippings change from the desired "best chippings" to undesirable spiral arc chippings.

28. In other words, the results for Samples Nos. 5-7 compiled in Table 1 show that, generally, as the amount of Cu is increased in the metal composition, the amount of β phase formation decreases. In these examples, the amount of Si is 2.4%. If the amount of Si is changed from 2.4%, then, depending on the amount of Si the β phase may not actually form, or conversely the β phase may form in excessive amounts (i.e., 20-30% of the phase construction), even though the amount of Cu in the metal composition remains constant.

29. Thus, while Samples Nos. 5 and 6 according to the present invention generate desirable chippings, Comparative Sample No. 7 does not. In other words, based on the nature of the chippings observed during the cutting test, it is apparent that Comparative Sample No. 7 does not have industrially satisfactory machinability. Comparison between Samples Nos. 5 and 6 of the present invention with Comparative Sample No. 7 shows that machinability of Cu-Zn(Pb) alloys depends greatly on the percentage of β phase in the metal construct. More particularly, the data proves that Cu-Zn(Pb) alloys made in accordance with the present invention, having a β phase of about 5% or less, are provided with a machinability that is satisfactory for our industrial purposes. On the other hand, similar Cu-Zn(Pb) alloys, such as represented by Comparative Sample No. 7, are not suited for industrial use due to significantly inferior machinability characteristics that result when the percentage of β phase reaches above

a critical value.

30. Discernable from the data in Table I is the fact that somewhere between 5 to 10% β phase the machinability of the metal alloy becomes unacceptable. Thus, it is critical that the machinability of Cu-Zn(Pb) metal alloys, made in accordance with the present invention, have a β phase that is not more than about 5%.

Effect of β Phase on Corrosion Resistance

31. Another fact discernable from the data in Table I is the fact that as the percentage of β phase reaches 10%, the corrosion resistance of the Cu-Zn(Pb) alloy of the present invention sharply declines. Specifically, the corrosion depth for Samples Nos. 5 and 6 is about 160 and 180 μm, respectively, when dipped in 1% aqueous cupric chloride dihydrate solution for 24 hours. On the other hand, the corrosion depth for Comparative Sample No. 7 is about 310 μm, which is almost two times greater. Thus, it is clear that the corrosion resistance of Cu-Zn(Pb) metal alloys, made in accordance with the present invention, is critically dependent upon having a β phase that is not more than about 5%.

32. I believe that a person skilled in the art would recognize that deterioration in corrosion resistance is a serious practical problem for those metal alloys intended to be used to manufacture metal water supply stopcocks and valves. Specifically, a lead containing metal alloy having poor corrosion resistance, such as represented by Comparative Sample No. 7, may have lower amounts of Pb than conventional free cutting brasses containing 3% Pb, but when the metal rapidly corrodes whatever amount of lead that is present would readily leach

into the water supply. Thus, an easily corroded Cu-Zn(Pb) metal alloy, such as represented by Comparative Sample No. 7, would be unsuitable for use in manufacturing components for water supply lines due to the health risk it would cause.

Effect of Extrusion Temperature on β Phase Formation

33. The data in Table I also demonstrates the affect of hot extrusion temperature on the percentage of β phase formation and various other characteristics of Cu-Zn(Pb) alloys made in accordance with the present invention. Specifically, when Sample No. 6 and Comparative Samples Nos. 9.1 and 9.2 are compared, it becomes apparent that decreasing the hot extrusion temperature from 750°C used in forming Sample No. 6 to 650°C used in forming Comparative Sample No. 9.2 produced no significant difference with regard to the percentage of β phase and $\gamma+\kappa+\mu$ phases formed in the metal phase construction. Consequently, there was no significant difference observed in the condition of chippings, cut surface state, cutting force required, and corrosion depth characteristics between Sample No. 6 of the present invention and Comparative Sample No. 9.2. On the other hand, when the hot extrusion temperature is increased to 800°C, such as is the case for Comparative Sample No. 9.1, the formation of β phase increases to 10% and the formation of the $\gamma+\kappa+\mu$ phases decreases to 10% in the metal construction. Corresponding changes in metal alloy properties are seen as a result of these changes in phase construction.

34. The metal phase construction of Comparative Sample No. 9.1 is similar to the phase construction in Comparative Sample No. 7, albeit this similar phase construction is the result of altering the hot extrusion temperature and not the metal composition. Consequently,

Comparative Sample No. 9.1 has metal alloy characteristics similar to Comparative Sample No. 7. In other words, Comparative Sample No. 9.1 requires a greater cutting force (i.e., almost 1.1-1.15 times that required for Samples Nos. 5, 6 and Comparative Sample No. 9.2), generates undesirable spiral chippings, and is significantly less corrosion resistant than Samples Nos. 5, 6 and Comparative Sample No. 9.2 (i.e., corrosion depth is almost twice).

35. The data in Table I shows the effect of hot extrusion temperature when forming Cu-Zn(Pb) alloys made in accordance with the present invention. When hot extrusion temperature is too high (i.e., around 800°C), an excess of β phase is formed thereby causing the following disadvantages: (a) an undesirable increase in cutting force, (b) the production of undesirable chippings during cutting, and (c) an undesirable decrease in corrosion resistance. As discussed above with respect to Comparative Sample No. 7, these disadvantages renders the metal alloy of Comparative Sample No. 9.2 unsuitable for manufacturing components for water supply lines in view of the industrially unsatisfactory machinability, the undesirable condition of the chippings, and in view of the unsatisfactory corrosion resistance.

36. As previously discussed, the kinds of phases formed, and the percentages of these phases, is not determined solely by the composition of the metal. Likewise, the formation of metal phase construction is not determined solely by the hot extrusion temperature alone. For instance, the Comparative Sample No. 9.1, which has the same metal composition as Sample No. 6, shows that when the processing method is also fixed, the referred extrusion temperature is determined to be about 750°C-800°C. In other words, from the particular fixed metal composition and processing method parameters used in making Samples Nos. 6 and 9.1, it is

evident that β phase formation in excess of 5% occurs around 750°C-800°C. However, the temperature range values of 750°C-800°C that make up the critical temperature range may fluctuate or shift to 760°C-830°C depending upon the diameter of the extruded metal ingots, the extrusion speed, and the selected processing method (e.g., the cooling speed).

37. Consequently, the critical extrusion temperature is determinable only when both a particular metal composition is selected and a particular processing method has been determined. Although an extreme case, it is possible to select a certain metal alloy composition and a certain processing method so that the β phase of the phase construction is maintained at 5% at all extrusion temperatures. In such a case, there would be no critical extrusion temperature.

Effect of Adding Tin to the Present Invention Alloys

31. When Sn is added to a metal alloy, the result is that the alloy becomes brittle and its Charpy Impact Value is lowered as explained using Example 3, described in paragraphs [0072] through [0075] of the present specification. Ductility is also lowered when Sn is included in the metal alloy. Alloys with a low Charpy Impact Value are not as suited for use as materials for making products needing caulking after the cutting process. That is to say, materials for such products need high impact resistance in addition to good machinability characteristics. Products needing caulking after the cutting process include, for example, tube connectors called nipples, metal pieces such as hinges for furniture, automobile sensor parts, and the like.

32. Table 9 of the present application contains a compilation of Charpy Impact Value comparison testing data between Cu-Zn(Pb) alloys manufactured with and without Sn. Table 9 of the present specification has been reproduced and attached herewith as Table II for the Examiner's convenience. The copper alloys (Nos. 1-6) are all listed as embodiments in the Specification of the present application. The data in Table 9 of the instant application demonstrates the great reduction in Charpy Impact Value caused by the addition of Sn to Cu-Zn(Pb) metal alloys. I believe those skilled in the art would be aware that the Charpy Impact Value can be obtained by dividing Charpy absorption energy by the notch sectional area, and that a material having a low Charpy Impact Value is a material having a small absorption relaxation ability against impact. In other words, a material that has a low Charpy Impact Value is a brittle material. As discussed in paragraph [0074] of the above-captioned specification, the impact test method employed to obtain the above results is the "Metal materials impact test method" categorized under JIS Z 2242. The testing machine was the "Charpy impact test machine" categorized under JIS B 7722, and the test pieces used were the "U notch test piece" categorized under JIS Z 2202.

33. As evident from Table 9 of the present specification, the Charpy Impact Values of Copper Alloys No. 2 and No. 5, both containing Sn, are far smaller than the Charpy Impact Values of Copper Alloys No. 1, No. 3, No. 4 and No. 6, which do not contain Sn. I believe this data conclusively shows that the addition of tin to Cu-Zn(Pb) metal alloys, such as those recited in claims 1-11 of the present application, would materially diminish the basic and novel Charpy Impact Value characteristics of the metal composition of the presently claimed invention.

Conclusions

34. In my expert opinion, the comparative data compiled in Table I attached hereto, and as explained above, supports the following conclusions:

(a) the percentage of β phase in the metal phase construction of Cu-Zn(Pb) metal alloys made in accordance with the present invention is dependent upon both the percentage of Cu in the alloy composition and the hot extrusion temperature used during formation of the alloy;

(b) the percentage of β phase in the metal phase construction of Cu-Zn(Pb) metal alloys made in accordance with the present invention has a profound effect on the machinability characteristics of the alloy (i.e., the cutting force required when machining and the condition of chippings produced when machining);

(c) the percentage of β phase in the metal phase construction of Cu-Zn(Pb) metal alloys made in accordance with the present invention has a profound effect on corrosion resistance of the alloy;

(d) the advantageous machinability and corrosion resistance characteristics of Cu-Zn(Pb) metal alloys made in accordance with the present invention are critically dependant upon having a percentage of β phase in the metal construction that is not more than about 5% as presently claimed;

(e) that Cu-Zn(Pb) metal alloys having β phase of 10% or more (i.e., Comparative Samples Nos. 1-4, 7, 8.1, 8.2, and 9.1), and which are otherwise similar to Cu-Zn(Pb) metal alloys of the present invention, are not suited for industrial application to the manufacturing of water faucets, water supply/drainage metal

fittings and valves, and like components for water supply lines, because the machinability of such alloys having excessive amounts of β phase is not acceptable (i.e., the cutting forces required and the condition of the chippings produced while cutting are unacceptable for industrial application);

(f) it can be reasonably inferred that the metal alloys of Examples A through C of the Nakashima Patent (the closest prior art) would be even less suited for industrial application to the manufacturing of water faucets, water supply/drainage metal fittings and valves, and like components for water supply lines, than comparative Samples Nos. 1-3 because the reported hardness of Nakashima's metal alloys would generally render their machinability impractical for our intended industrial application;

(g) that the relatively poor machinability characteristics of Comparative Sample No. 4, which corresponds to Example D of the Nakashima Patent, was congruent with the reported hardness of such a Cu-Zn(Pb) alloy (i.e., Hardness Rockwell B value of 95, see Table 1 in the Nakashima Patent); and

(h) that the addition of tin to the metal alloy compositions recited in claims 1-11 of the present invention would materially diminish the basic and novel Charpy Impact Value characteristics of these metal compositions.

35. I declare under penalty of perjury that the foregoing is true and correct, that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements so made are punishable by fine or

imprisonment, or both, under 18 U.S.C. § 1001 and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Signed by,

Date: April 2, 2004 Keiichiro Oishi

Keiichiro OISHI

TABLE I

Sample No.	Cu	Si	Pb	Zn	Al	Mn	Fe	Ni	Other elements	Metal phase constr.	$\gamma+\kappa+\mu$ (%)	β (%)	Condition of Chippings	Cut Surface State	Cutting Force (N)	Corrosion Depth (μm)	Hot Extrusion Temperature (°C)
Comp. 1	62.3	0.5	0.2	27.6	3.5	0	1.0	3.9	1.0 Co	$\alpha+\beta$	0	90	x	○	216	----	750
Comp. 2	60.1	0.6	0.2	32.0	5.4	0	0.7	0	1.0 Zr	β	0	100	x	○	224	----	750
Comp. 3	57.2	0	0.2	34.8	4.9	0	1.4	1.0	0.4 Ti, 0.4 Nb	β	0	100	x	○	227	----	750
Comp. 4	56.8	1.0	0.2	38.2	1.5	2.3	0	0	----	β	0	100	x	○	218	----	750
5	72.6	2.4	0.15	24.9	0	0	0	0	----	$\alpha+\gamma+\beta$	15	~ 1	●	○	118	160	750
6	71.1	2.4	0.15	26.4	0	0	0	0	----	$\alpha+\gamma+\beta$	15	5 or less (~ 4)	●	○	123	180	750
Comp. 7	69.5	2.4	0.15	28	0	0	0	0	----	$\alpha+\gamma+\beta$	10	10	Δ	Δ	138	310	750
Comp. 8.1	56.8	1.0	0.2	38.2	1.5	2.3	0	0	----	β	0	100	x	○	217	----	800
Comp. 8.2	56.8	1.0	0.2	38.2	1.5	2.3	0	0	----	β	0	100	x	○	218	----	650
Comp. 9.1	71.1	2.4	0.15	26.4	0	0	0	0	----	$\alpha+\gamma+\beta$	10	10	Δ	Δ	137	310	800
Comp. 9.2	71.1	2.4	0.15	26.4	0	0	0	0	----	$\alpha+\gamma+\beta$	15	5 or less (~4)	●	○	122	170	650

Notes:
1. The hot extrusion of Comparative Samples Nos. 1-4 and 7 and Samples Nos. 5 and 6 was carried out with ingots heated to 750°C.
2. The hot extrusion of Comparative Samples Nos. 8.1 and 9.1 was carried out with ingots heated to 800°C.
3. The hot extrusion of Comparative Samples Nos. 8.2 and 9.2 was carried out with ingots heated to 650°C.
4. Comparative Samples Nos. 8.1 and 8.2 have the same metal alloy composition as Comparative Sample No. 4.
5. Comparative Samples Nos. 9.1 and 9.2 have the same metal alloy composition as Sample No. 6 of the present invention.

TABLE II: Impact Test Results*

[wt%]

Copper Alloys No.	Cu	Si	Pb	Sn	P	Zn	Sharpy Impact Value (J/cm)
1	75.1	2.8	0.06	--	--	Remainder	59.10
2	75.0	2.6	0.06	1.07	--	Remainder	12.20
3	75.3	2.7	0.05	--	0.11	Remainder	63.00
4	76.7	3.0	0.06	--	--	Remainder	73.40
5	77.0	3.0	0.05	1.00	--	Remainder	9.90
6	77.1	3.1	0.05	--	0.10	Remainder	63.40

*This table is a reproduction of Table 9 of U.S. Patent Application Serial No. 09/434,498, filed October 22, 2001.